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Performance of Medium Duration Rice Cultivars on Growth, Productivity and Profitability under South Andaman Condition of India

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ABSTRACT

A field experiment was carried out during both July to November 2019 and 2020 on the farmers' fields in the Guptapara village of South Andaman, India, to determine the growth and yield performance of a medium-duration rice cultivar and its suitability. The treatments included five medium-duration rice cultivars consist of Jaya, ADT 45, CARI dhan 3, CARI dhan–6, and CARI dhan-7 laid out in Randomised Complete Block Design with four replications. The results showed that medium-duration rice cultivars exhibited significant variations in growth and yield attributing characteristics, such as leaf area index, root length, root dry weight, the number of productive tillers m^{-2}, panicle length, filled grains $panicle^{-1}$, and test weight. The growth attributes of rice were significantly influenced by medium-duration rice cultivars, except plant height. Regardless of the duration of the rice cultivars, CARI dhan 7 exhibited significantly greater root length and dry weight, measuring 33.2 cm and 6.37 g $hill^{-1}$, respectively. CARI dhan 7 had substantially higher productive tillers (357 m^{-2}), filled grains $panicle^{-1}$ (121.6), grain (4790 kg ha^{-1}), and straw yield (7390 kg ha^{-1}), which was statistically comparable to CARI dhan-6. CARI dhan 7 had the highest gross return of ₹ 71595 ha^{-1}, a net return of ₹ 36946 ha^{-1}, and a benefit-cost ratio of 2.07. The medium-duration rice cultivar CARI dhan 7 performed better and more suitable in low-lying areas of South Andaman.

KEYWORDS: Economics, productive tillers, root characters, rice, variety, yield

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Rice is one of the world's most important food crops, reaching 782 mt of food production in 2021. However, more than 200 mt of rice production is estimated to be required to meet the demand within 30 to 40 years (Makino et al., 2020; Flora et al., 2023). In India, more than 65% of the people depend on rice, which plays a crucial role in national food security and provides employment generation and livelihood security to 70% of the Indian population. The demand for rice is rapidly increasing due to the steadily growing Indian population, and 130 million tonnes of rice will be required by 2025. Andaman and Nicobar Islands, rice occupies an area of 7650 ha in rainfed low-lying conditions with an average productivity of 2.3 to 2.7 t ha^{-1}, necessitating an import of about 27,188 tonnes of rice from the mainland (Damodaran et al., 2014; Subramani et al., 2023a) due to adoption of low yield cultivars and high intensity of rainfall and wind velocity cause crop lodging during maturity stage. Island farmers are growing traditional photo-sensitive rice varieties of C-14-8, which is low-yielding and poorly responsive to any external input use efficiency. The productivity of rice is primarily linked to the duration of its growth. During a specific growth phase, the productivity of rice increases as the duration of growth is extended. The total number of days in the growth period is a significant factor that limits the yield (Wang et al., 2016; Huang et al., 2018; Chen et al., 2022). Each rice variety has its distinct genetic potential, which exclusively affects its yield attributing characters and ultimately yield under varying environmental conditions reported (Pattnaik et al., 2019). Although the dominant *kharif* rice varieties, such as Ranjit and Bahadur, have a high yield potential, they take a considerable amount of time (150–155 days from seed to seed) to reach maturity. These characteristics are not desirable for farmers who intend to cultivate vegetable crops like brinjal and okra on the same piece of land for the next season (Das et al., 2018). Explore high-yielding rice varieties to boost factor productivity, lower farming costs, boost profits, and optimise input use (Dekhanel et al., 2023). The yield gap can be reduced using improved genotypes with proper crop management practices depending on the growth characteristics of different cultivars to obtain higher yield potential from new genotypes (Bommayasamy and Chinnamuthu, 2021). Nowadays, high-yielding rice cultivars have gained much importance over the past few decades due to low yield and the overgrowing population of India. However, the introduction of semi-dwarf rice varieties and the large-scale use of agrochemicals such as fertilizers and pesticides have changed the dynamics of pest and disease incidences of rice (Jamir and Gohain, 2017). Rice cultivar plays a unique role in productivity maximization by enhancing the input use efficiency as the genetic potential limits the expression of its productivity. It affects plant growth in response to environmental conditions (Bommayasamy et al., 2020). Medium-duration rice cultivars provide higher yield-attributing components and productivity because they have more periods for biomass growth and accumulation (Subramani et al., 2023b). Medium-duration cultivars are alternative cultivars of short-duration cultivars, and the adoption of modern agricultural practices enhances the productivity of rice. With the above facts, the present study was carried out to compare the growth and yield attributing characters of different medium-duration rice cultivars at farmers' fields under South Andaman condition.

2. MATERIALS AND METHODS

On-farm trials were conducted from July to November, 2019 and 2020 in a farmer's field in Guptapara village, South Andaman (744105), India which is geologically located in India's Islands agroclimatic zone (11°38' N latitude and 92°39' E longitude, with an altitude of 10 m above MSL) and receives an average annual rainfall of 3080 mm. The experimental soil had a clay loam texture, a pH 6.8, and an EC of 0.2 dS m^{-1}. It contained organic carbon (0.3%), available nitrogen (150.2 kg ha^{-1}), phosphorus (9.7 kg ha^{-1}), and potassium (112.4 kg ha^{-1}). The experiment was carried out using a randomised complete block design with four replications. The treatments include five medium-duration rice cultivars: Jaya, ADT-45, CARI dhan-3, CARI dhan-6, and CARI dhan-7. Pre-germinated rice seeds were sown in wet seed during the second week of July, and transplanting was completed with three seedlings per hill at a spacing of 20×15 cm^2 in the second week of August. Due to the higher rainfall on islands, farmers were advised to apply fertiliser in split doses. In medium-duration varieties, the recommended NPK dose of 90:60:40 kg ha^{-1} was used as urea, rock phosphate, and potash. Nitrogen was applied in three equal amounts 10 days after planting, maximum tillering, and panicle initiation. The total phosphorus and half potassium were used as a basal, with the remaining 50% potassium applied at the panicle initiation stage. The field was puddled with a tractor-drawn cage wheel to reduce percolation losses and keep a thin layer of soil during the growing season. Because islands receive more rainfall, there is no need to supply irrigation water. As a result, farmers strengthened their field bunds and stored rainwater in the field itself. During heavy rains, adequate drainage facilities were made to drain excess water from the field. Butachlor at 1.25 kg a.i. ha^{-1} was used as a pre-emergence herbicide to control early-stage weeds, while late-emerging weeds were controlled by hand weeding at 40 DAT. Pest and disease management was carried out on a need basis. Yoshida (1972) standard procedures for recording growth and yield

attributes were followed. The grain yield of each plot was determined by sun-drying, cleaning, and weighing the grain at a moisture level of 14%. However, three days of sun drying and separate weighing were applied to the straw. The yields of grain and straw were measured in kilogram per hectare. The expenses incurred in cultivation, total revenue, and net profit were calculated for each treatment, considering the current market prices for inputs, produce, and labour wages. The data collected from experiments were pooled and analyzed followed as Gomez and Gomez (1984) recommended.

3. RESULTS AND DISCUSSION

3.1. Plant growth characteristics

The heights of the plants showed a steady and gradual rise in all medium-duration rice varieties from the stage of transplanting and extended up to the stage of harvest. The growth attributes of rice were significantly influenced by medium-duration rice cultivars, except plant height (Table 1). Although no significant variation was observed in plant height, there were numerical differences between them. Jaya dhan was the tallest plant among the recorded heights, as its height was 12.8% greater than that of CARI dhan 3. Krishnan et al. (2011) and Hussain et al. (2014) observed that a rapid increase in plant height indicated that the crop had gone from the vegetative phase to the reproductive phase of growth. The leaf area index of CARI dhan 7 was recorded as 5.78%, significantly higher than that of CARI dhan 6. The higher leaf area index was attributed to an increased number of total tillers and leaves per unit area, with minimal variation in leaf breadth (Rajput et al., 2016). Jaya dhan exhibited the smallest leaf area. The phenology of cultivars, specifically the root system, is an essential trait that influences the cultivars' capacity to extract water and nutrients from various soil profiles (Fageria et al., 2014). Rice cultivars significantly impact root growth parameters, such as root length and root dry weight. CARI dhan 7 exhibited significantly greater root length and dry weight, measured at 33.2 cm and 6.37 g hill^{-1}, respectively. The photosynthetic rate of rice is influenced by the leaf area index and canopy structure, which in turn affects the production of dry matter (Bommayasamy et al., 2020; Yun, 2023). Regardless of the duration of the rice cultivars, CARI dhan 7 exhibited a significantly higher number of total tillers at a rate of 636 m^{-2}, which was similar to that of CARI dhan 6. The subsequent optimal treatment option was CARI dhan 3 and ADT-45.

Table 1: Performance of medium duration rice cultivars on growth attributes of rice

Treatments	Plant height (cm)	LAI*	Root characters*		Plant biomass accumulation (kg ha^{-1})
			Root length (cm)	Root dry weight (g hill^{-1})	
T_1: Jaya	124.9	4.49	23.9	5.42	8988
T_2: ADT 45	114.1	4.83	25.2	6.18	9678
T_3: CARI Dhan 3	110.7	5.47	29.6	6.31	10665
T_4: CARI Dhan 6	113.2	5.75	30.1	6.36	11293
T_5: CARI Dhan 7	117.4	5.78	33.2	6.37	11310
SEd	5.0	0.27	1.9	0.29	380
LSD (p≤0.05)	NS	0.58	4.1	0.63	828

*Flowering stage

3.2. Crop yield characteristics

The medium-duration rice cultivars exhibited significant variations in yield-attributes such as the number of productive tillers m^{-2}, panicle length, filled grains panicle^{-1}, and test weight (Table 2). CARI dhan-7 had a significantly higher number of productive tillers, with 357 m^{-2}, statistically equivalent to the number observed in CARI dhan 6. These two cultivars exhibited a 38.3% and 27.2% increased in productive tillers m^{-2} compared to Jaya dhan. The primary reason for this is the robust growth of plants, enhanced absorption of nutrients, and improved accumulation of dry matter, resulted in a subsequent rise in the production of productive tillers (Bommayasamy and Chinnamuthu, 2021; Paul et al., 2021). Medium-duration rice cultivars efficiently utilised natural resources such as photoperiods and temperature to promote vigorous growth and development. This results in increased nutrient absorption for protoplasm synthesis and rapid cell division, ultimately enhanced the plant's stature and size due to the genetic characteristics of the cultivar. There was no significant difference in the percentage of unproductive tillers among rice cultivars with a medium duration. Nevertheless, the percentage of CARI dhan 3 was more significant (47.3%) compared to other cultivars. The potential factor might be a heightened asynchrony in tiller production, which is associated with intensified competition for resources such as space, nutrients, water, air, and light in both the above ground and below ground environments. The plant's routine physiological functions are impeded by this competition. Kumar et al. (2017) found that improved high yielding cultivars produced more tillers, improved crop growth and development, and increased photosynthetic efficiency due to higher LAI at flowering and physiological maturity.

Table 2: Performance of medium duration rice cultivars on yield attributes, yield and economics of rice

Treatments	Productive tillers m^{-2}	Panicle length (cm)	Filled grains $panicle^{-1}$ (nos.)	Test weight (g)	Yield (kg ha^{-1})		Harvest index (%)	B:C
					Grain	Straw		
T_1: Jaya	258	20.5	74.8	21.6	3780	5500	42.1	1.75
T_2: ADT 45	287	23.5	93.2	18.7	4210	5920	43.5	1.88
T_3: CARI Dhan 3	295	24.8	83.6	23.5	4380	6780	41.1	1.94
T_4: CARI Dhan 6	329	24.6	102.3	22.4	4560	7050	40.4	1.99
T_5: CARI Dhan 7	357	25.7	121.6	24.8	4790	7390	42.4	2.07
SEd	18	1.1	4.3	1.4	234	294	2.5	-
LSD ($p \leq 0.05$)	40	2.4	9.4	3.0	509	641	NS	-

1 US$= INR 71.47 (2019) and INR 74.26 (2020)

CARI dhan 7 exhibited a longer panicle length of 25.7 cm, like that of CARI dhan 6, CARI dhan 3, and ADT 45. CARI Dhan 7 had the highest number of filled grains $panicle^{-1}$. Subsequently, there were CARI dhan 6 and ADT 45. The variation in the genetic potential of rice cultivars significantly influenced the number of filled grains $panicle^{-1}$. Bommayasamy et al. (2010) found that sufficient nutrient availability, improved root growth and increased light interception, enhanced panicle production and increased the size and number of spikelets. Subramani et al. (2014) reported similar findings. The test grain weight is a pivotal attribute used to evaluate yield, as it is an inherited characteristic that is minimally influenced by the environment. Test weight is a dependable indicator of the overall quality of grains and serves as the main criteria for evaluating them. There was a significant difference in grain test weight among medium-duration rice cultivars. CARI dhan 7 substantially increased test grain weight of 24.8 g. Roy et al. (2014) reported that the variance in the genetic potential of a cultivar is likely responsible for the differences in the test grain weight. The data presented in Table 2 indicates that the medium-duration rice cultivar known as CARI dhan-7 exhibited the highest grain yield, followed by CARI dhan 6 and CARI dhan 3. These three rice cultivars showed similar characteristics. The higher yield of CARI dhan 7 might be attributed to its superior ability to convert photosynthates into economic produce, led to better conversion rates. Pradhan et al. (2014); Bommayasamy and Chinnamuthu (2018); Subramani et al. (2023); Naik et al. (2023) observed that increased photosynthetic efficiency and improved translocation of photosynthates to the grain might have led to enhanced grain fullness and weight, fertility percentage, and grain production. The cultivar CARI dhan 7 achieved the highest straw yield of 7390 kg ha^{-1}, primarily attributed to its plant stature, high tiller production capacity, and vigorous growth. The medium-duration rice cultivar did not show any significant difference in the harvest index. However, there was a notably higher yield of 43.5% in ADT 45. The increased harvest index could be attributed to a more efficient allocation of photosynthesis towards the production of straw and a higher proportion of grain in the overall biomass yield of the rice cultivar. Sohel et al. (2009); Damodaran et al. (2012), who have documented that an elevated harvest index might be attributed to a greater number of tillers, increased leaf area, and higher total dry matter production. Jaya dhan had recorded the lowest yield of grain and straw. Possible causes include inadequate tillering, reduced filled grains per panicle, and the cultivar's susceptibility to lodging.

3.3. Economics

The enhanced grain productivity of medium-duration rice cultivars had increased gross and net income led to higher benefit-cost ratio. The economic analysis showed that CARI dhan 7 had the highest gross return of ₹ 71595 ha^{-1}, a net return of ₹ 36946 ha^{-1}, and a benefit-cost ratio of 2.07. This cultivar generated a profit of ₹ 11045/- higher than the Jaya. The increase in economic values could be attributed to the substantial grain and straw yield enhancement. Jaya Dhan recorded the lowest gross return, net return, and B:C ratio. Kumar et al. (2013); Damodaran et al. (2015) observed that certain yield attributing characteristics were associated with better crop yield, which led to increased gross and net returns.

4. CONCLUSION

CARI dhan 7 was recorded at 4790 kg ha^{-1} and was found more suitable for low-lying areas of South Andaman for profitable rice farming. Farmers recognized and preferred CARI dhan 7 for synchronized maturity and timely harvest under higher rainfall conditions.

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